1 Introduction

MIPP-Note: MIPP-NOTE-HARD-9

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Purpose: Calibration of four 'Group3 Digital Hall effect Teslameters'

Date data was taken: 10/24/02 to 10/25/02

To monitor the magnetic field in the JGG and Rosie throughout the data taking, two Hall probes each will be mounted at the top and bottom center of each magnet. During field-mapping these Hall Probes will also give the absolute calibration to the Ziptrack.

The regions of interest are around 0.73 T (JGG) and -0.6 T (Rosie). The maximum field is 1.4 T using Rosie.

2 The Hall Probes

The probes are produced by 'Group3 Technologies' (see http://www.group3technology.com/probes.htm). The model 'LPT 141' is used. The probes have a suffix '7m' or '7s' to the model number. The probe head size is $14 \times 14 \times 2.5$ mm^3 with an active area of 4×1.6 mm^2. It is specified as reading up to 3 T with an accuracy of 0.01% at 25°C, has a temperature coefficient of ± 5 ppm/°C and a zero drift of ± 1 mT/°C. The probes can be operated at temperatures from 0 to 50°C.

The probe has a 'personality module' attached inside the connector on the cable. This stores the initial calibration. The probe head can be housed in an aluminum mounting bracket. The probe is read out by a module with GPIB interface. The display shows six digits and the sign of the field. In the range up to 1.2 T the last digit is even and in the range to 3.0 T the last digit is either 0 or 5.

3 Setup

The calibration was done using the GMW Model 3474 Electromagnet in IB1. Work was performed by Holger Meyer and Walt Jaskierny. The magnet with 150 mm poles at a spacing of ca. 48 mm has a large region of uniform field.

Two different NMR probes with overlapping ranges from 0.35 T to 1.05 T and 0.7 T to 2.1 T were used with the NMR system to measure the absolute field inside the magnet. NMR probe and Hall sensor were cable tied to the mechanical support previously used for Hall probe calibrations by the people in IB1 (Darryl Orris, etc.).

The coordinate system is defined with z along the B field direction with positive polarity of the power supply, i.e. negative z is left, positive z is right for a person standing in front of the setup). The y direction is up and thus negative x is in front of the setup, positive x behind the magnet. The origin is in the center of the gap in the magnet.

The setup allows for precise translations in the y and z directions and rotation around the x direction. Positioning in the x direction is achieved by pushing the support stand with respect to the magnet, as is rotation around the y direction. Rotation around the z direction is basically impossible with the existing setup and of course is not needed, since the z axis is a rotational symmetry of the setup. The two coarse adjustments (rot y and trans x) were sufficient to adjust to the highest reading on the Hall probe. The sensitivity of the reading on both NMR and Hall probe was examined using the precisely adjustable degrees of freedom (rot x and trans y). In the z direction the effect of translation was examined and measurements were taken such that the two probes (NMR and Hall) were located symmetrically in the gap around the center. The field was found to be uniform better than the quoted precission of the Hall probes (0.01%) for more than 2 cm in either direction from the center. With the Hall Probe touching the magnet pole the field changed by 1 Gauss out of 9000 Gauss. No error was introduced due to field inhomogeneity. Another concern is to adjust both the Hall probe and the NMR so that they are normal to the field. This setting was found for the Hall probe by turning 90 degrees around x to find the zero field reading. Then the probe was turned back by 90degres0minutes. This did (as expected) result in the maximum reading. Further the maximum reading on the Hall probe was unchanged for rotations of 10minutes to 30minutes, depending on probe. Rotations of this magnitude correspond to translations of a few mm on one side of the mounting fixture. Thus it was easily possible to find the maximum reading for rotation around the y direction, too. The NMR was cabel tied to the same support as the Hall Probe. It was less sensitive to rotations when it

ser. #	p_0	p_1	p_2	p_3
1141267	0.000395633	1.00001e+00	-4.29045e-05	-4.45616e-05
1141404	8.69114e-07	1.00021e+00	-4.23348e-05	-6.60542e-05
1141363	0.000432367	1.00002e+00	-0.000121638	-0.00010343
1141268	0.000648142	9.99399e+01	-2.82526e-05	-4.60704e-05

Table 1: Calibration parameters for four Hall probes.

was almost normal to the field. It did not need independend adjustments and was reading the maximum value when the Hall Probe was aligned.

Note that the Hall probe was mounted such that the field along the negative z direction was measured.

Note also that the first two probes were calibrated with more measurements taken near 0.73 T while the last two probes have more data near 0.6 T.

Note also that the reading of the Hall probe was made using the appropriate range setting (changing between the 3 T and 1.2 T ranges when changing the field between 1.2 T and 1.1 T), except in the calibration of the first probe where all measurements with the higher range NMR were done in the 3 T range setting. The last Hall probe was read out with both range settings at the 1.2 T field. The readouts were 1.20010 T and 1.20022 T, deviating from each other by 1 G. The value from the 3 T range was used in the calibration.

4 Results

The data has been fitted using ROOT. A polynomial of third degree describes the data points well. In the plot (figure 1) for each probe the magnetic field as measured in the NMR is plotted against the Hall probe reading (left pannel). The right pannel shows the difference of the Hall probe reading and the NMR plotted against the NMR. This shows that the fit is good. Data points do not deviate by more than $\sim 10^{-4}$ from the fit. It also shows by how much the Hall probe readings deviate from the true magnetic field without the recalibration. The fits in the left and right pannel for each probe are inverse functions of each other (to better than 10^{-6} over the range from -1.6 T to +1.6 T). The parameters given in table 1 are from the first fit, taking a Hall probe reading and returning the true field.

It is noticable that one probe (1141268) shows a strong correlation of the reading with the true field. This could indicate that the NMR and the Hall Probe were not aligned during the calibration. However, great care was taken during calibration and so I think that the new calibration is correct for all four Hall probes.

5 Raw Data

The raw data points are listed in table 2.

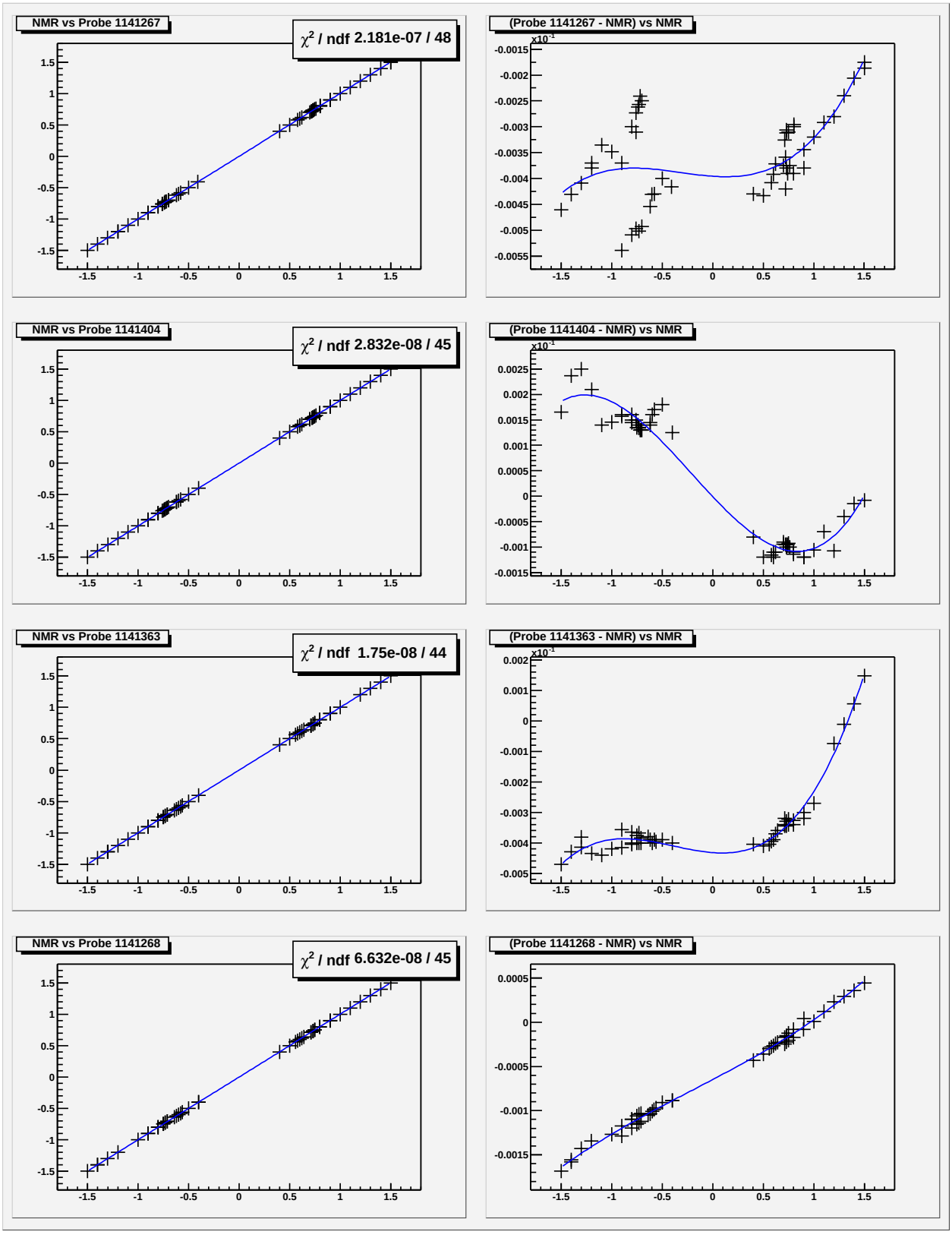

Figure 1: Calibration plots for four Hall probes

ser. No. 01141267		ser. No. 01141404		ser. No. 01141363		ser. No. 01141268	
NMR [T]	Hall [T]	NMR [T]	Hall [T]	NMR [T]	Hall [T]	NMR [T]	Hall [T]
0.406804	-0.40722	0.902457	-0.90230	0.899743	-0.90010	0.898745	-0.90003
0.500080	-0.50048	0.800145	-0.80000	0.799575	-0.79994	0.799105	-0.80030
0.579710	-0.58014	0.750295	-0.75016	0.749944	-0.75032	0.748785	-0.74994
0.600909	-0.60134	0.730274	-0.73014	0.729872	-0.73024	0.728940	-0.73008
0.620306	-0.62076	0.710050	-0.70992	0.709876	-0.71026	0.708979	-0.71010
0.699967	-0.70046	0.620220	-0.62008	0.639780	-0.64016	0.638930	-0.63998
0.729458	-0.72996	0.620205	-0.62006	0.619710	-0.62010	0.619125	-0.62016
0.760183	-0.76068	0.580230	-0.58006	0.599680	-0.60008	0.599030	-0.60004
0.800371	-0.80088	0.500200	-0.50002	0.579710	-0.58010	0.579150	-0.58014
0.900261	-0.90080	0.399945	-0.39982	0.559743	-0.56014	0.559130	-0.56010
		0.600360	-0.60020	0.499630	-0.50002	0.499030	-0.49994
1.499889	-1.50035			0.399660	-0.40006	0.399295	-0.40018
1.399919	-1.40035	-0.900560	0.90044			0.399275	-0.40016
1.300041	-1.30045	-0.800234	0.80012	-0.900840	0.90054		
1.199530	-1.19990	-0.750313	0.75022	-0.800487	0.80016	-0.900560	0.90060
1.199520	-1.19990	-0.730120	0.73002	-0.750523	0.75020	-0.800220	0.80014
1.099815	-1.10015	-0.700270	0.70018	-0.730450	0.73012	-0.750345	0.75022
1.000002	-1.00035	-0.619950	0.61984	-0.710400	0.71006	-0.730220	0.73006
0.899630	-0.90000	-0.600120	0.60000	-0.710380	0.71006	-0.730170	0.73002
0.799850	-0.80015	-0.600050	0.59994	-0.640500	0.64014	-0.710210	0.71004
0.760140	-0.76045	-0.580276	0.58016	-0.620350	0.61998	-0.640410	0.64018
0.760127	-0.76040	-0.500040	0.49992	-0.600430	0.60004	-0.620424	0.62018
0.739888	-0.74015	-0.400560	0.40048	-0.580395	0.58000	-0.600265	0.60000
0.719909	-0.72015			-0.560485	0.56008	-0.580280	0.58000
0.730143	-0.73040	-1.500308	1.50030	-0.500450	0.50004	-0.560460	0.56016
0.699950	-0.70020	-1.400415	1.40040	-0.400505	0.40010	-0.500380	0.50002
		-1.300240	1.30020			-0.400570	0.40014
0.701375	0.70100	-1.200157	1.20005	-1.500053	1.50020		
0.720770	0.72035	-1.100070	1.10000	-1.400095	1.40015	-1.499605	1.50005
0.720809	0.72045	-1.000066	0.99996	-1.300212	1.30020	-1.399690	1.40005
0.730930	0.73055	-0.900220	0.90010	-1.200225	1.20015	-1.299710	1.30000
0.741090	0.74070	-0.800290	0.80018	-1.000350	1.00008	-1.199770	1.20000
0.760875	0.76050	-0.760200	0.76010	-0.900360	0.90004	-1.099820	1.09994
0.800990	0.80060	-0.740095	0.74000	-0.800540	0.80020	-1.000130	1.00014
0.901180	0.90080	-0.730035	0.72994	-0.750280	0.74994	-0.900000	0.89992
1.001020	1.00070	-0.720175	0.72008	-0.730445	0.73010	-0.800110	0.79994
1.101042	1.10075	-0.700154	0.70006	-0.710565	0.71022	-0.750325	0.75012
1.200780	1.20050					-0.730445	0.73022
1.300840	1.30060	1.500665	-1.50050	1.499830	-1.50030	-0.710525	0.71028
1.400556	1.40035	1.400337	-1.40010	1.399720	-1.40015		
1.500525	1.50035	1.300500	-1.30025	1.299785	-1.30020	1.498466	-1.50015
1.500537	1.50035	1.200310	-1.20010	1.299769	-1.30015	1.398570	-1.40015
		1.100340	-1.10020	1.199615	-1.20005	1.398542	-1.40010
0.900644	0.90030	1.000026	-0.99988	1.099680	-1.10012	1.298770	-1.30020
0.803420	0.80312	0.900180	-0.90002	0.999740	-1.00016	1.198755	-1.20010
0.803416	0.80312	0.800260	-0.80010	0.899745	-0.90016	0.998790	-1.00006
0.750390	0.75008	0.800190	-0.80004	0.799655	-0.80006	0.898825	-0.90000
0.730332	0.73002	0.760410	-0.76026	0.799620	-0.80002	0.799060	-0.80016
0.730326	0.73002	0.740080	-0.73994	0.749640	-0.75004	0.799020	-0.80012
0.710346	0.71002	0.730175	-0.73004	0.729640	-0.73004	0.749140	-0.75020
0.620512	0.62014	0.720270	-0.72014	0.709620	-0.71002	0.729100	-0.73014
0.600572	0.60018	0.700290	-0.70016			0.709170	-0.71020
-0.580428	0.58002						
-0.500293	0.49986						
-0.400470	0.40004						

Table 2: Raw calibration data.